Ministerie van Verkeer en Waterstaat

Rijkswaterstaat

Dutch Approach to flood protection

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Outline

I. History of Dutch Water management.

II. Present approach to safety in the Netherlands.

III. Investigation of future (risk-based) approach of safety

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Part 1: History of Dutch Water management

History of flood disasters and Deltaplan

Introduction

A good flood protection system is necessary in the Netherlands because:

- Almost 60% of our country is threatened by water (storm surge on the North Sea or/and flooding due to high river discharge)

- We earn 70% of our gross national product in these flood prone areas

- Large cities like Amsterdam (capital) and Rotterdam (harbor) are below sea level

Historical development of flood defense

The battle against water in not new for the Dutch, the strategy however is different over time:

- Before 1000 AC: Try to avoid **damage and consequences** (e.g. living on high ground or mounds)

- 1000 – 2000: Try to **reduce the probability of flooding** (construction works/building levees)

- 21st century: Combination

Dike breach at Ochten (1784)

Mound at Hogebeintum

Defense system developed after disasters

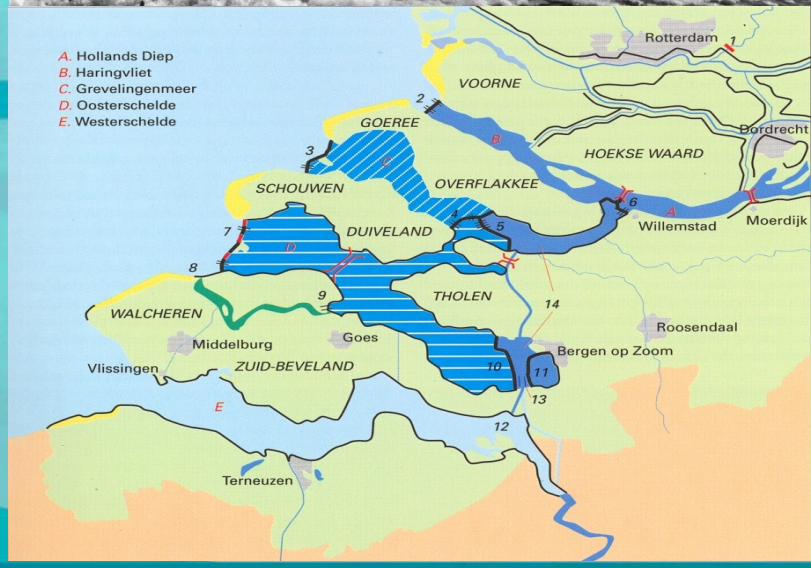
- Flooding in 1916 of the so called “Zuiderzee area”, construction of large dam
- And land reclamation works (Wieringermeer, Noordoostpolder, Flevoland)

Deltaplan and development safety standards

Flooding in 1953 (1800 people died)

Deltaplan:

- Closing of estuaries with dams and storm surge barriers (shortening coastline 700 km)
- Safety standards:
  - For the coast based on economic value. Western part of the Netherlands 1/10.000 years
  - South western part and the north 1/4000 year.
- Safety standard along the main rivers later (1956-1977-1993): 1/1250 year



The Easternscheldt Barrier

The Stormsurge barrier near Rotterdam

- New insights were incorporated in the Deltaplan, e.g. partly open systems, preserving unique tidal eco-system (environment and or shipping)
- In total over 50 years invested about 15 billion US dollars

Permanent attention needed !

Recent events:

- Extreme river discharges in 1993 and 1995 nearly overtopped our dikes, 250.000 people were evacuated
- Failure of secondary waterdefense in august 2003

Climate change:

- Sea level rise 20-80 cm/century
- Increased river discharge up to 40 %

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Part 2: Current approach to safety

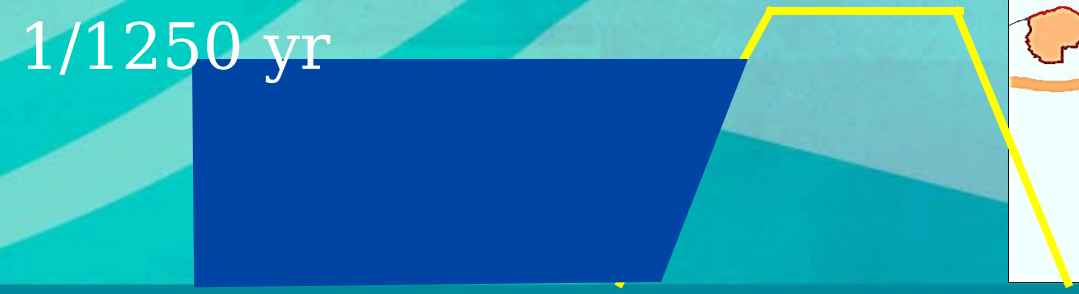
Standards, legislation and safety assessment

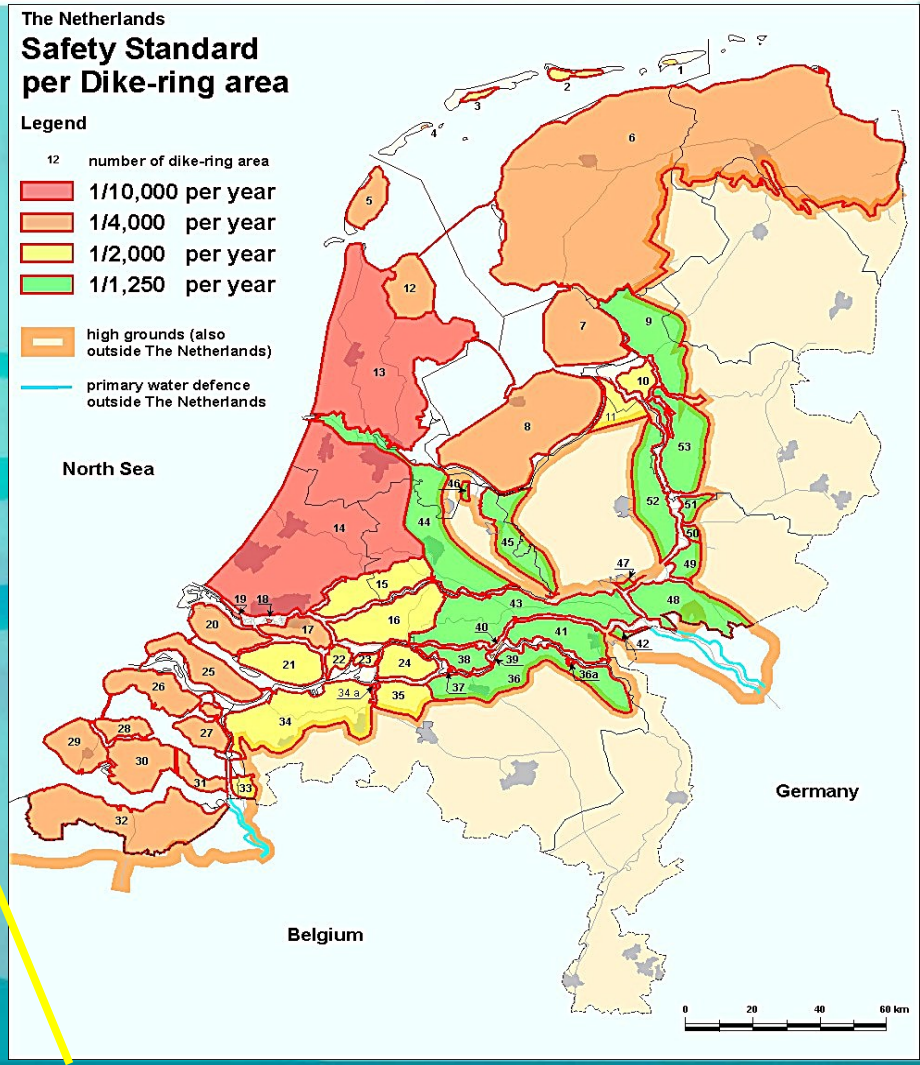
Flood defense system

Flood protection act and current standards

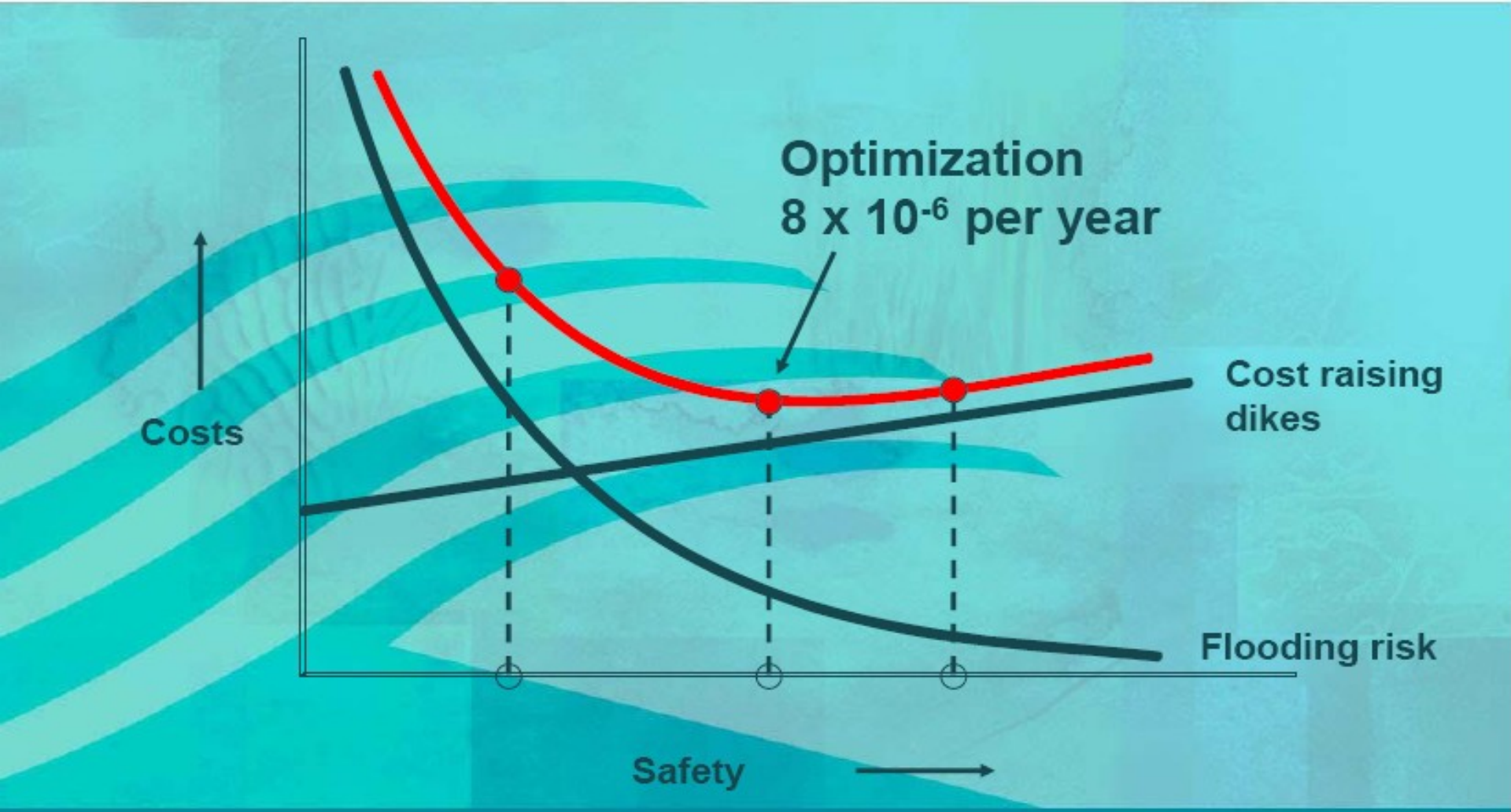
Flood protection act (1996):

- Issued in 1996 with the objective to durably **maintain the achieved safety** level
- Safety standard per dikering area
- Responsibility of the different parties (water boards, provinces, national government)
- Enforcement of safety assessment every 5 years

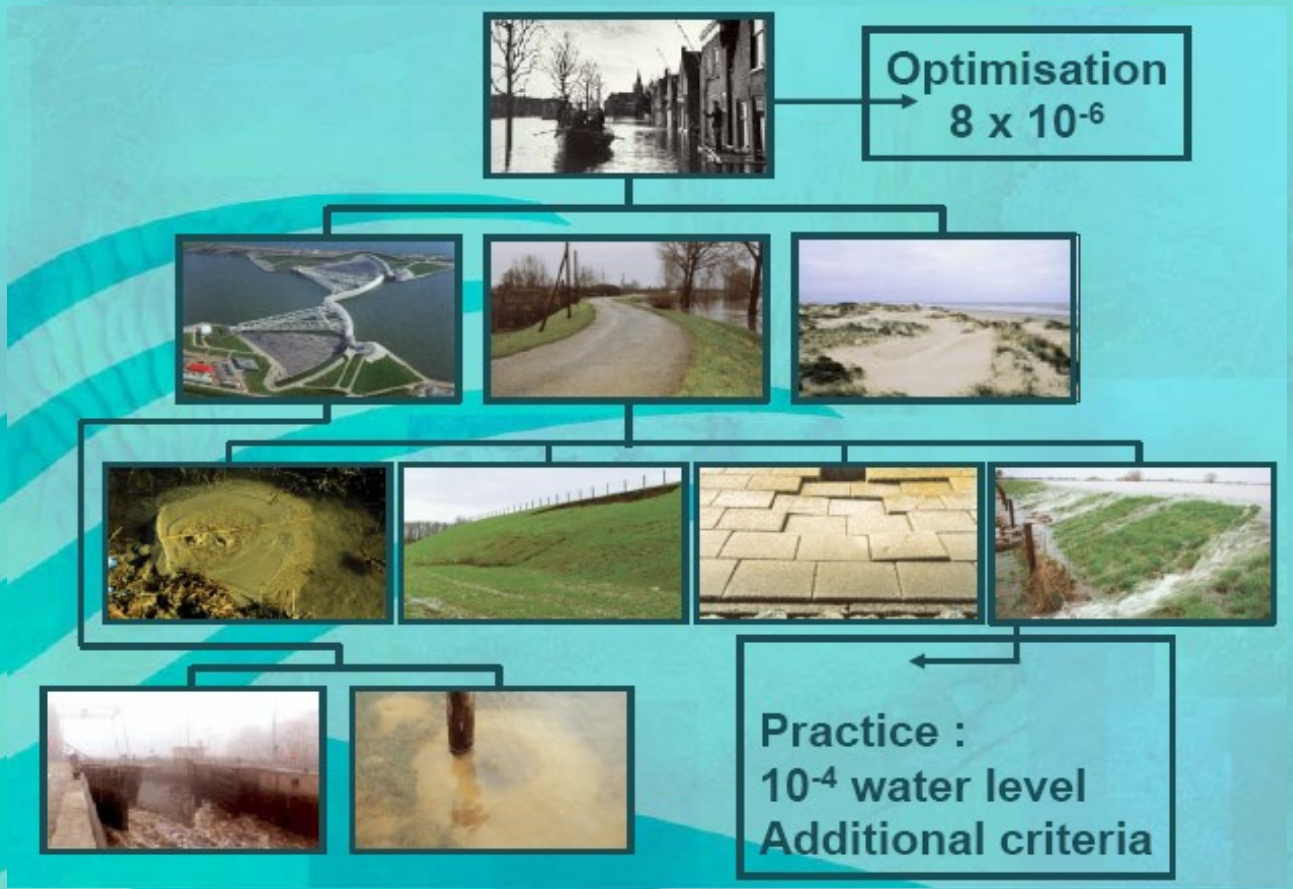




Economic optimization (1956)



Engineering application of standards



elements

Failure mechanisms

Distribute safety standard over **elements** and **failure mechanisms**

-> practical engineering criteria developed

Application in practice

- **Overtopping:**
  - Pr (overtopping exceeding critical volume) < safety standard

- **Other failure modes:**
  - Pr (failure due to other failure modes | no overtopping) < safety standard / 10
- **Guidelines**
  - These two design criteria form up till today the basis for the technical guidelines.
  - The technical guidelines also give the tools how to include technical developments (such as sea level rise, land subsidence)

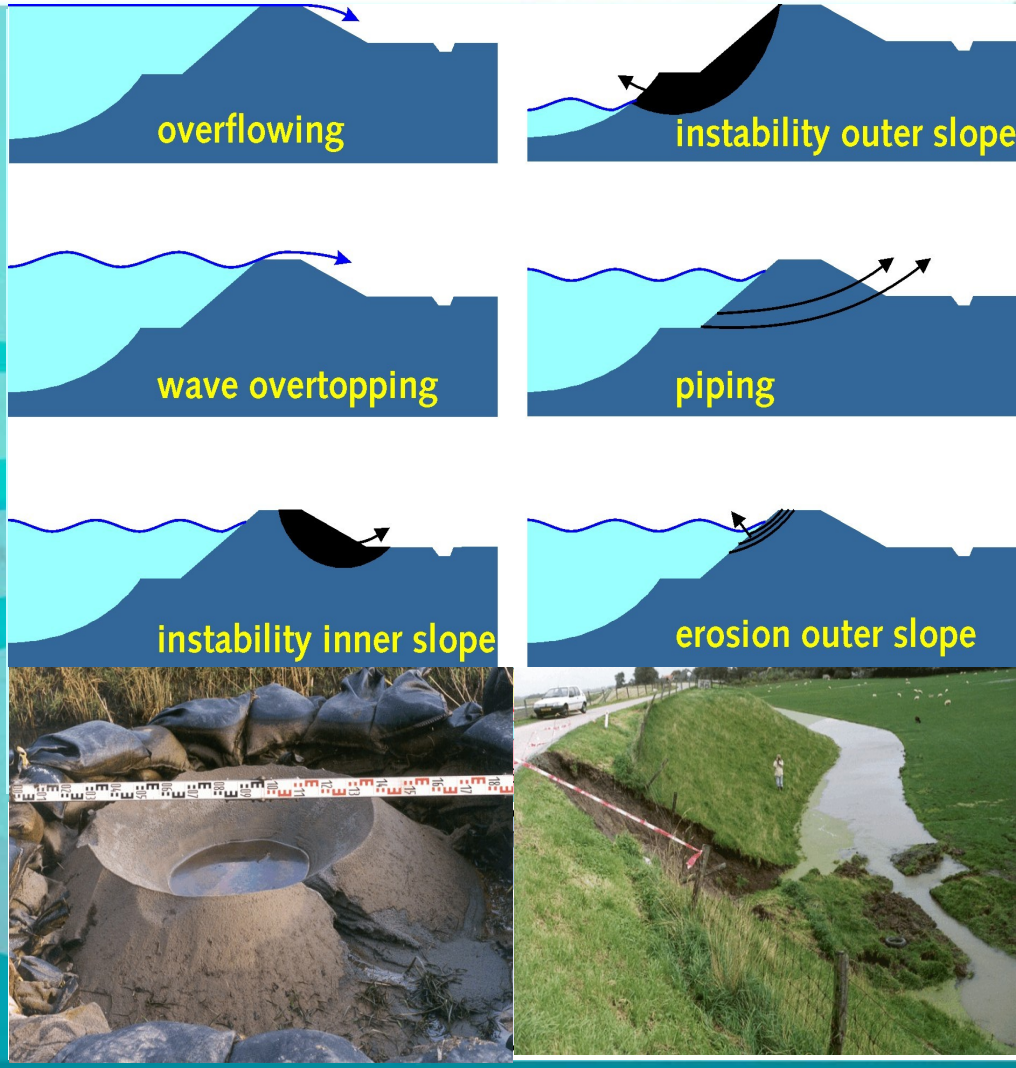
Safety assessment

Safety assessment:

- Carried out every 5 years by the local waterboards
- Comparison between strength of a water defenses and the (hydraulic) loads

Provided and set by the central government:

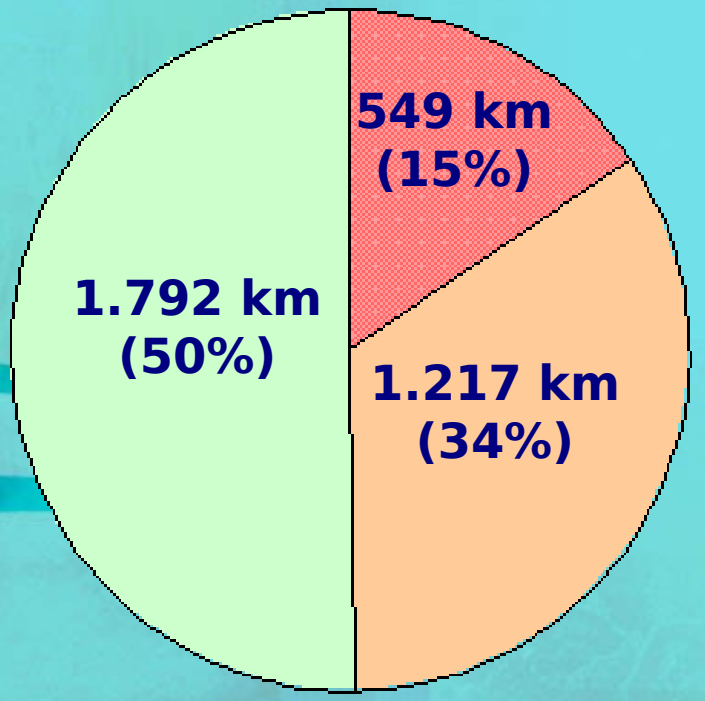
- Hydraulic boundary conditions (e.g. waterlevel, wave height and wave period)
- Technical design rules for each failure mechanism



Results of first safety assessment

Results of first safety assessment:

- Carried out for 3558 km primary water defense
- Results reported to the Parliament in 2003.
- 50% according to required standard
- 15 % not according to standard
- 35 % uncertain, research needed



Different type of measures

When safety standards of the Flood Protections Act are not met reinforcements are carried out (e.g. revetment)

- If uncertain further research needed (e.g. soil characteristics)

- Overall costs of reinforcement works until 2015 about **4.2 billion Euro**

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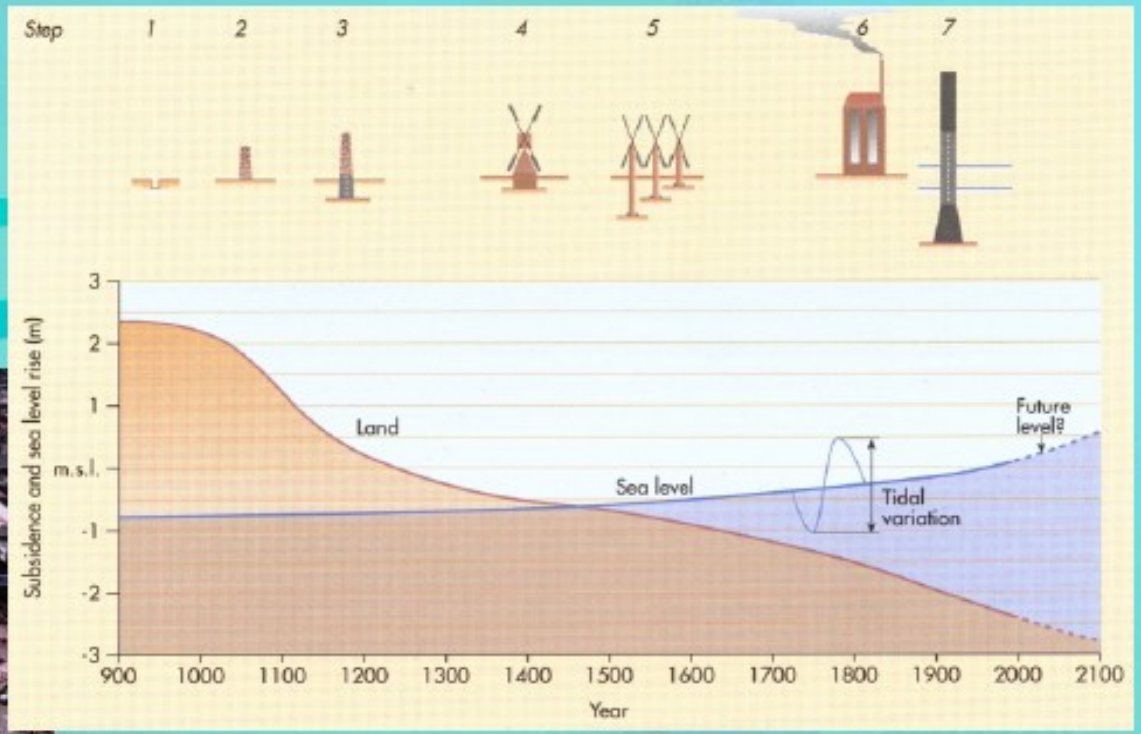
Part 3: Investigation of future (risk-based) approach

Future developments

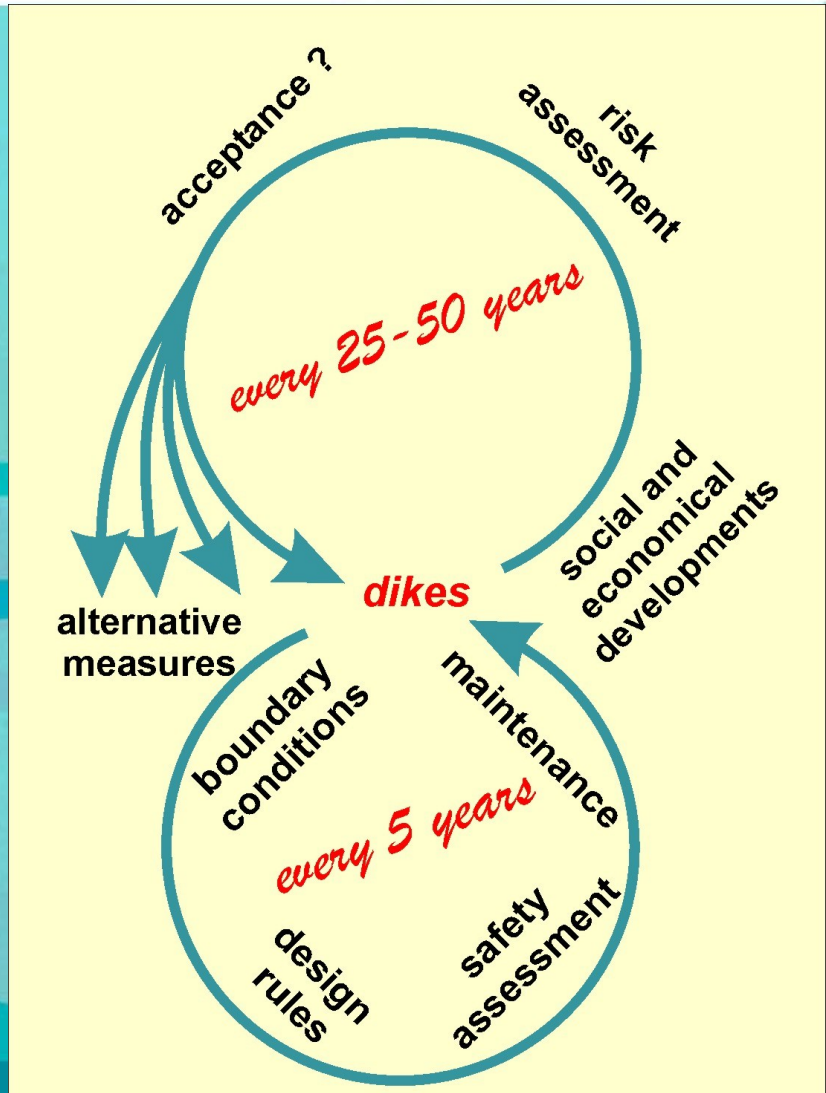
Where do we go from here?

- sea level rise
- drainage, compaction
- societal developments



Are we still safe enough?

- Standards set in 1960's, growth since then:
  - Population from 10 to 16 million
  - Economy: NNP from 17 to 350 billion **€**
- Risk assessment: Evaluate whether current flood defence system offers sufficient protection to societal values
- Are policy changes needed?
  - Living with water / Space for water



Towards a risk based approach of flood defence

Risk = Probability of Flooding X Consequences

Why? To achieve a level of protection that is in balance with societal value (Cost Benefit Analysis)

Methods developed in 1990's, by technical institutes in cooperation with Rijkswaterstaat

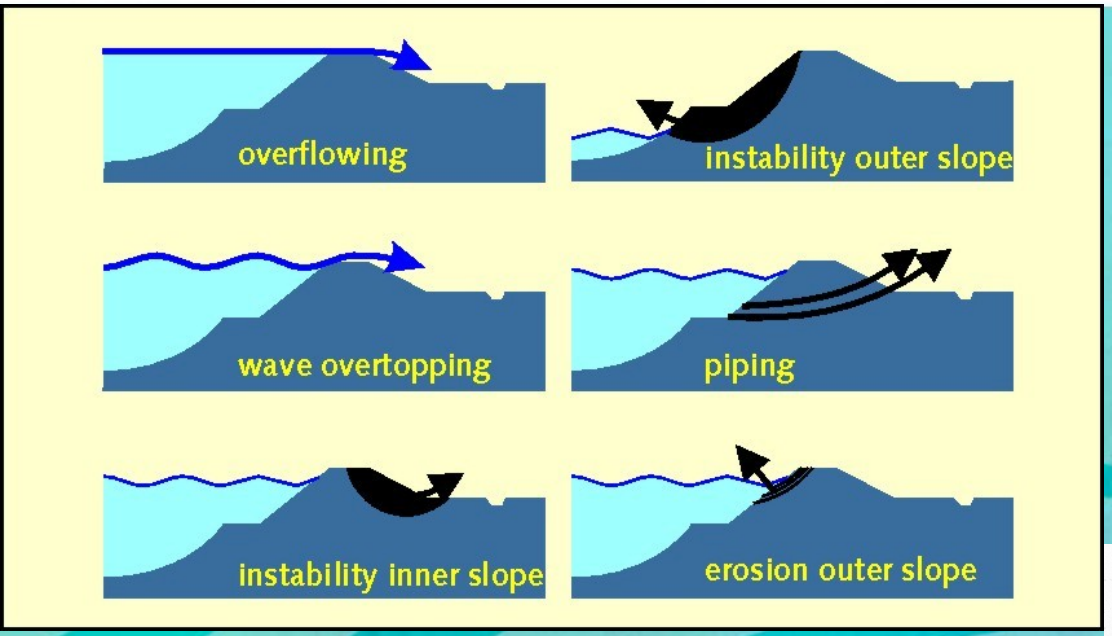
Probability of exceedance -> Probability of flooding

- Until now: probability of exceedance of design water level
- New concept: actual probability of flooding

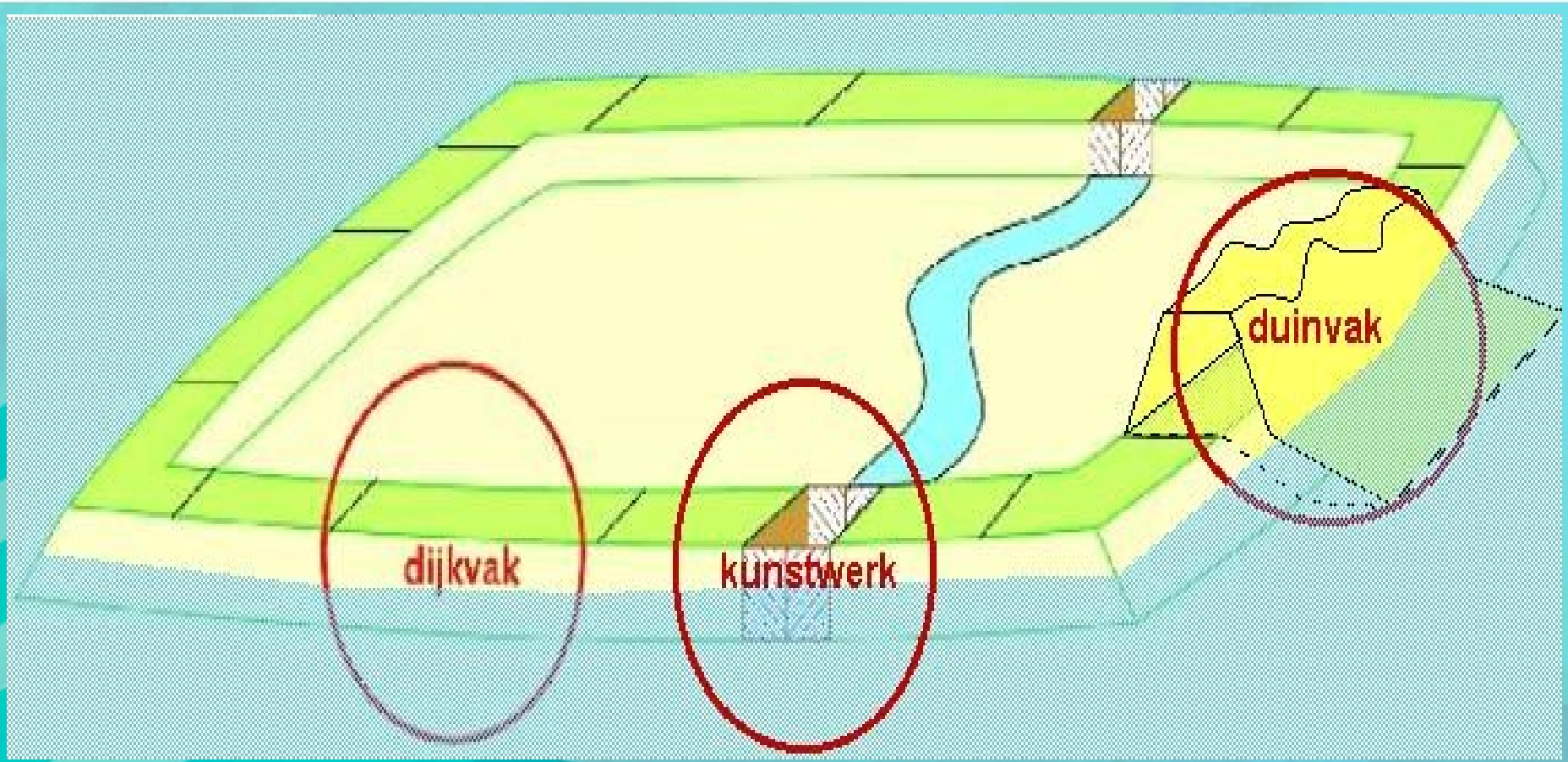
Difference:

- Multiple **failure mechanisms**
- From dike section to **dike ring**
- Systematic discounting of **uncertainties**

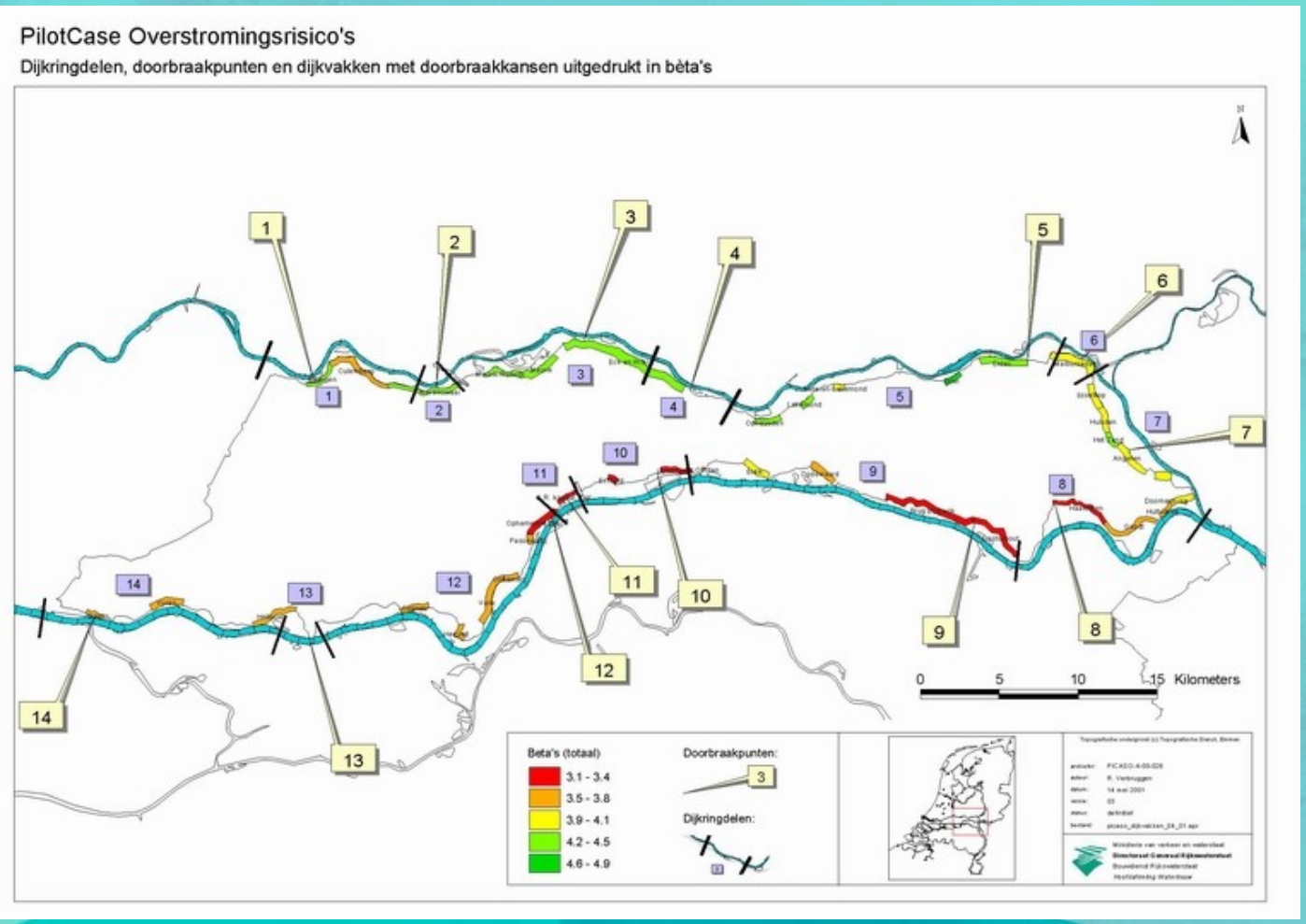
Failure mechanisms



Dike ring concept



Flooding probability: example



- Take into account local circumstances and mechanisms
- Dike ring is like a ‘chain’
- Identify weak spots

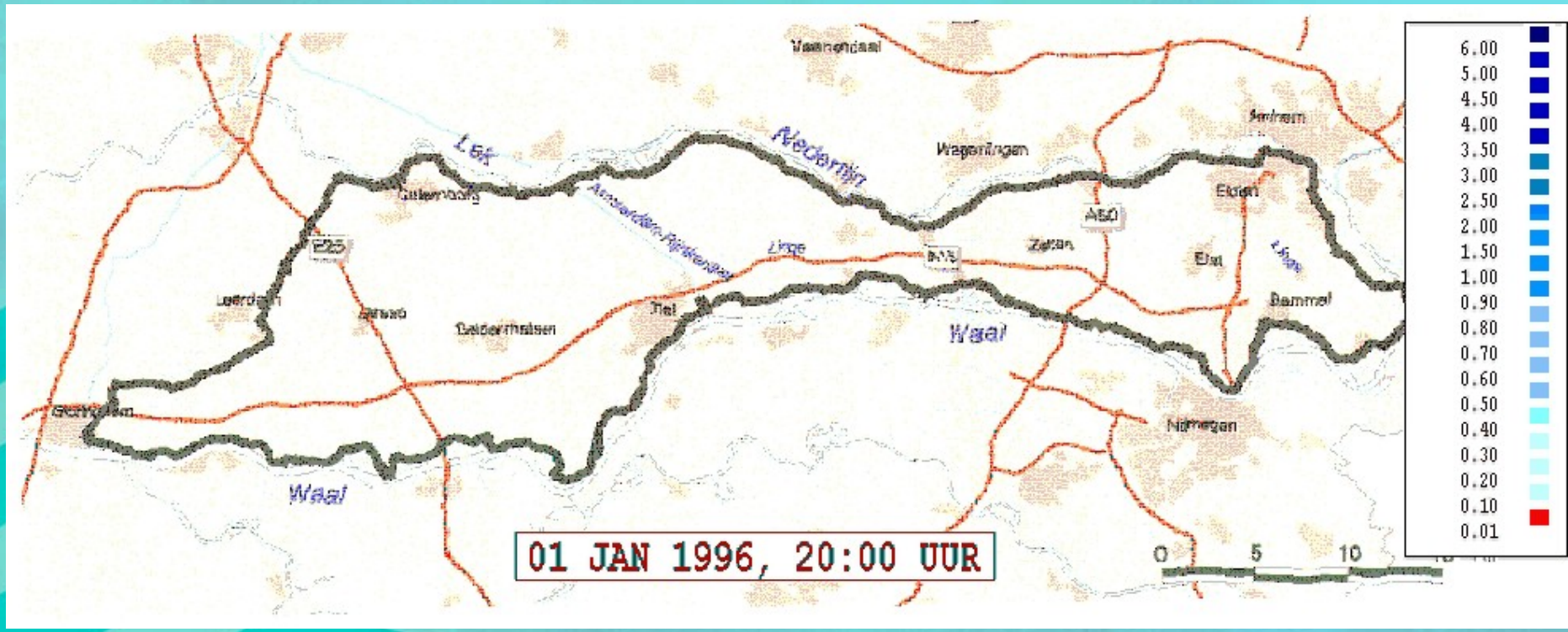
Damage assessment

Based on output of flood simulations

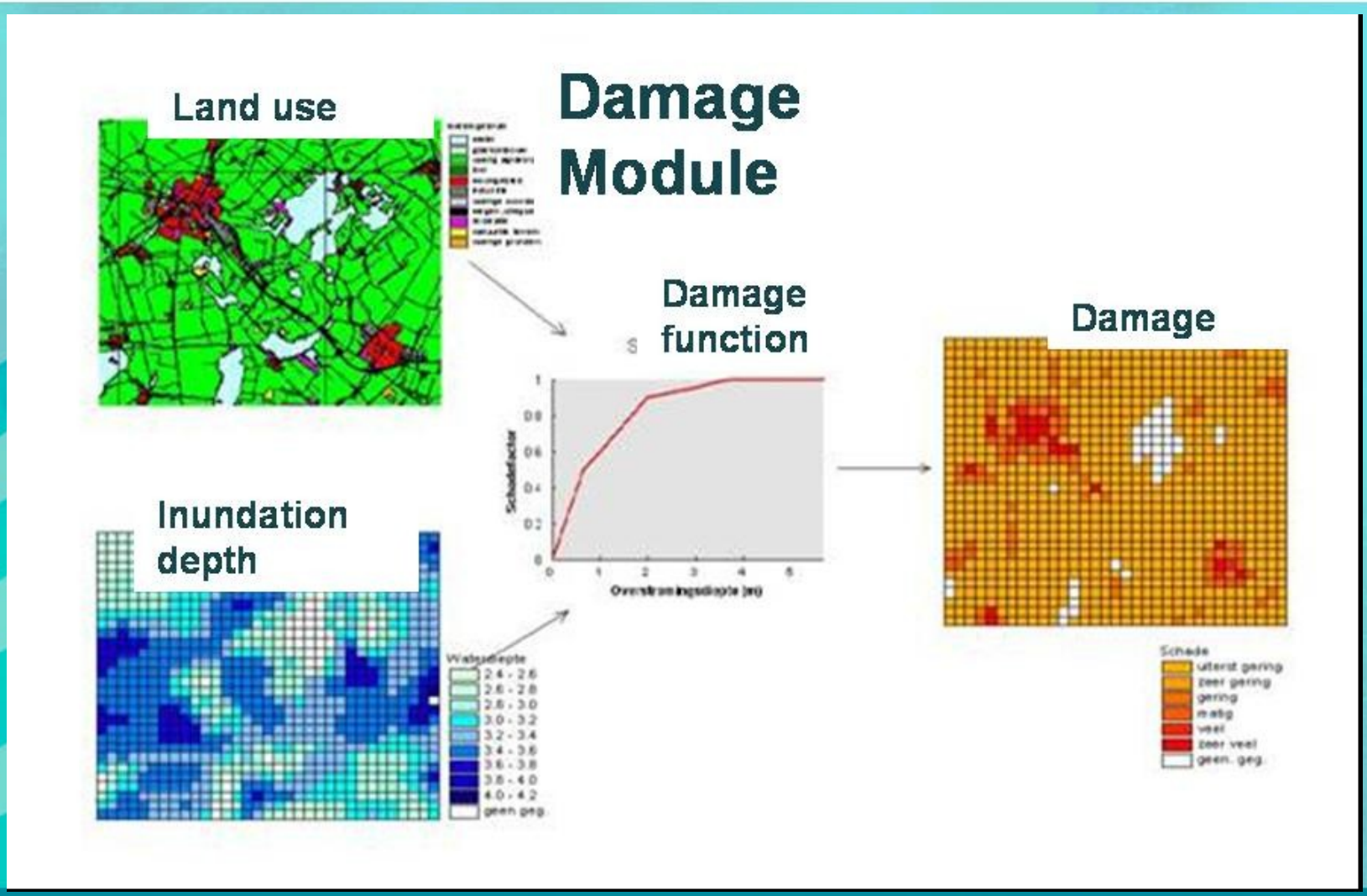
Two types of consequences considered:

- Economic damage
- Loss of life and possibilities for evacuation

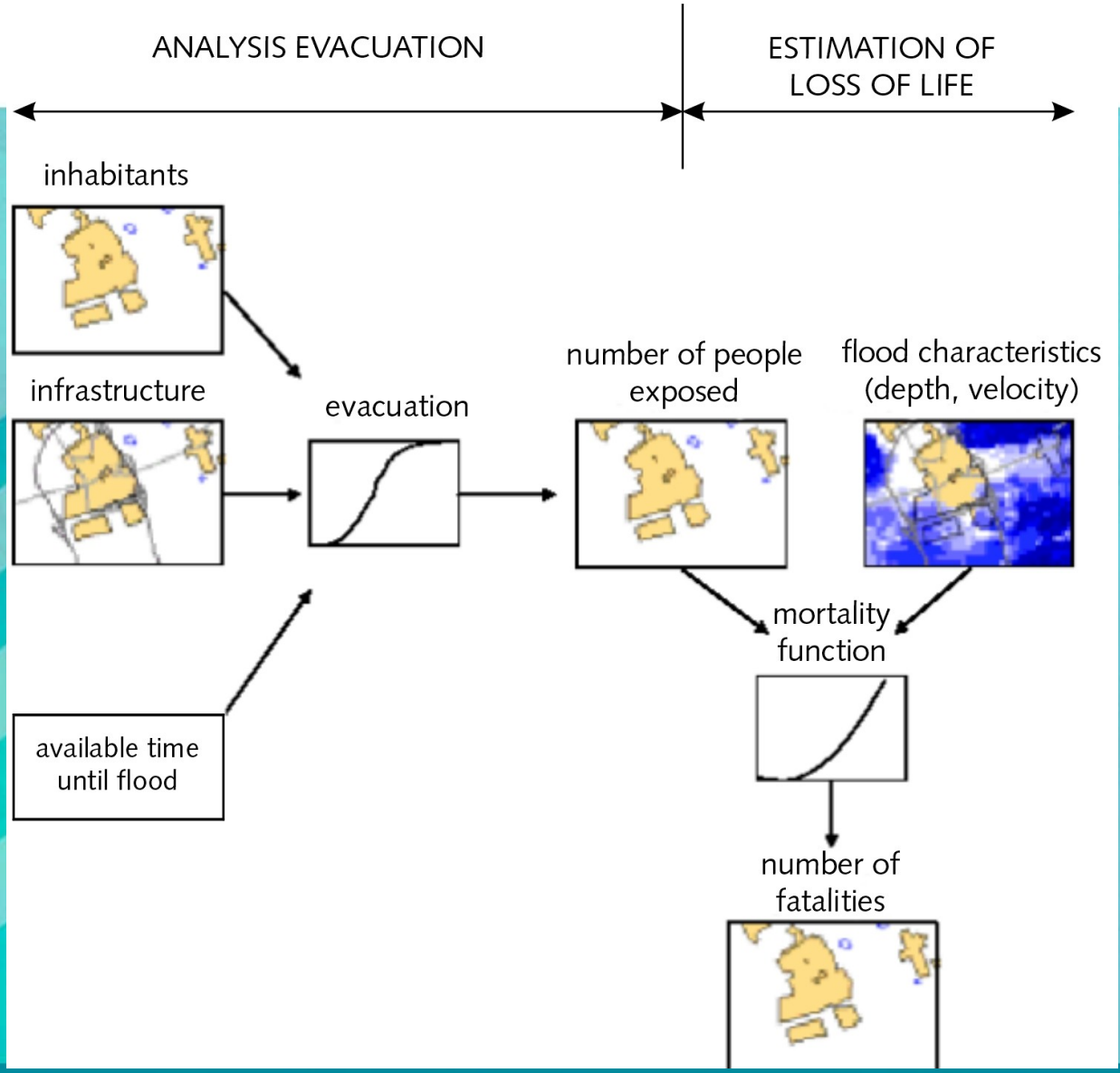
Flood simulation



Economic damage assessment

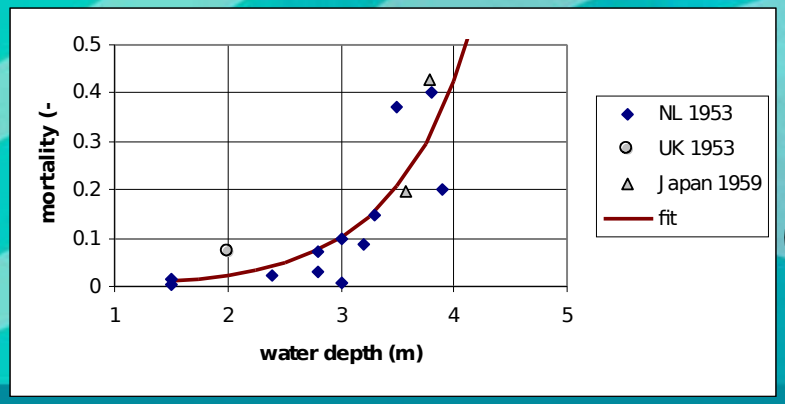


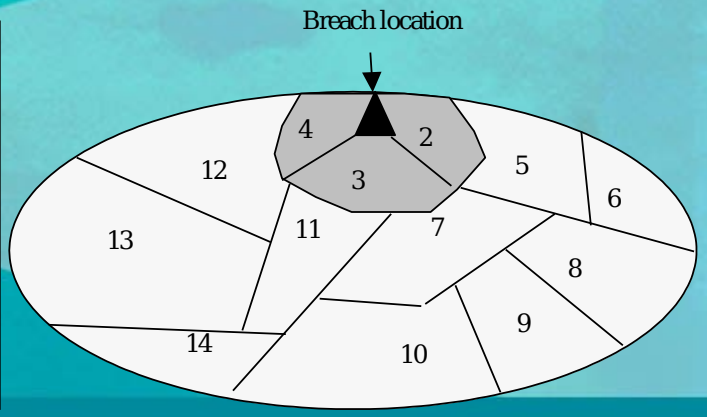
Loss of life estimation



Mortality functions

- Mortality function: relates mortality (amongst those exposed) to flood characteristics
- Developed for 1953
- three hazard zones with typical mortality patterns:
  - Near breach
  - Rapidly rising water
  - Remaining zone





Results 2005: Flood risk analysis (VNK)

- Method applied in practice
- 16 dike ring areas
- Future: whole country analysed as a basis for discussion on adjustment of safety standards

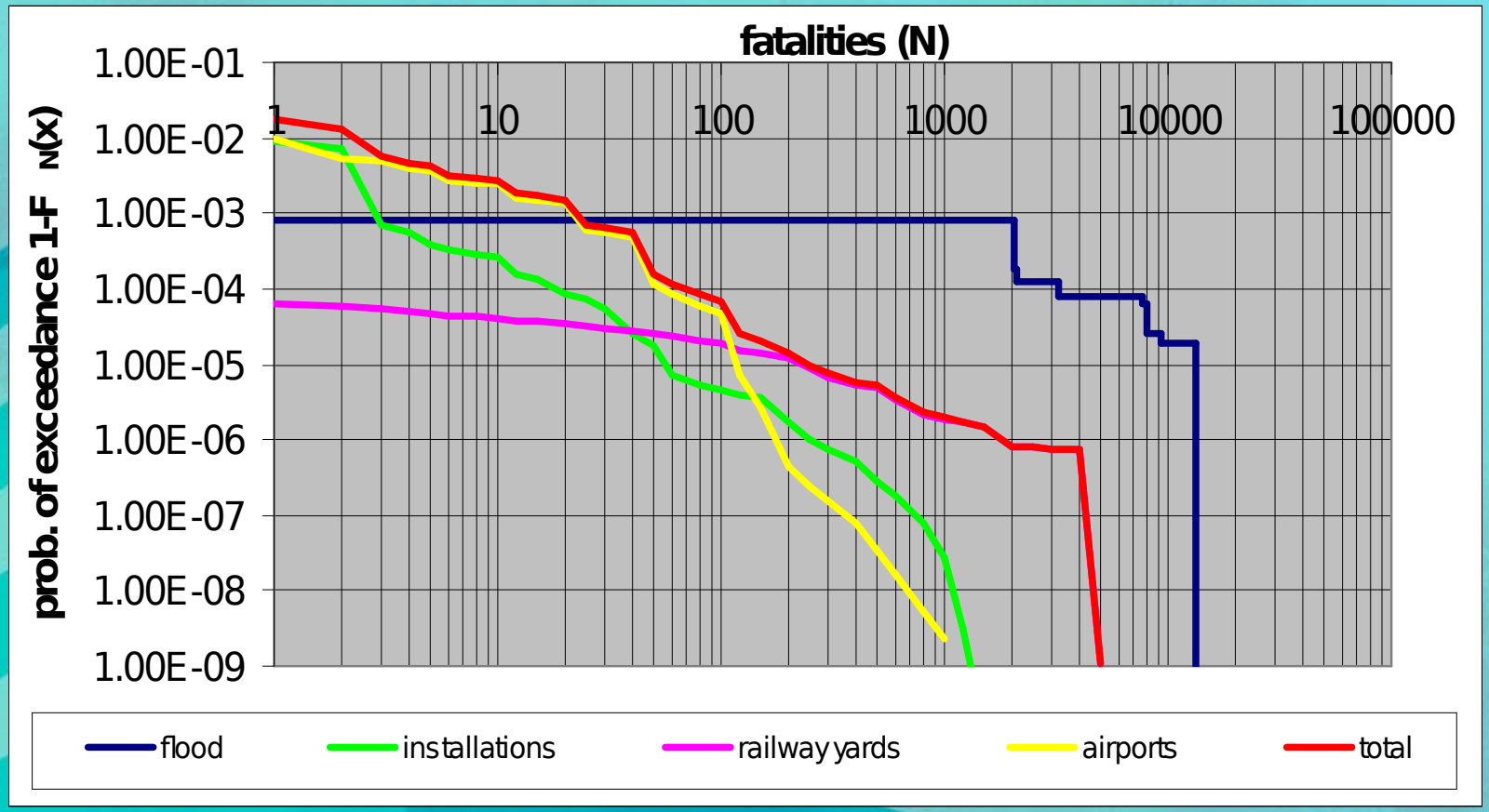
Results 2005: Flood risk analysis (VNK)

Dike ring	Probability (1/yr)	economic damage* (billion €)	Loss of life#
Noordoost-polder	1/900	1.9	5-1400
South Holland	1/2500	5.8	30-6100
Land van Heusden	>1/100	3.7	5-800

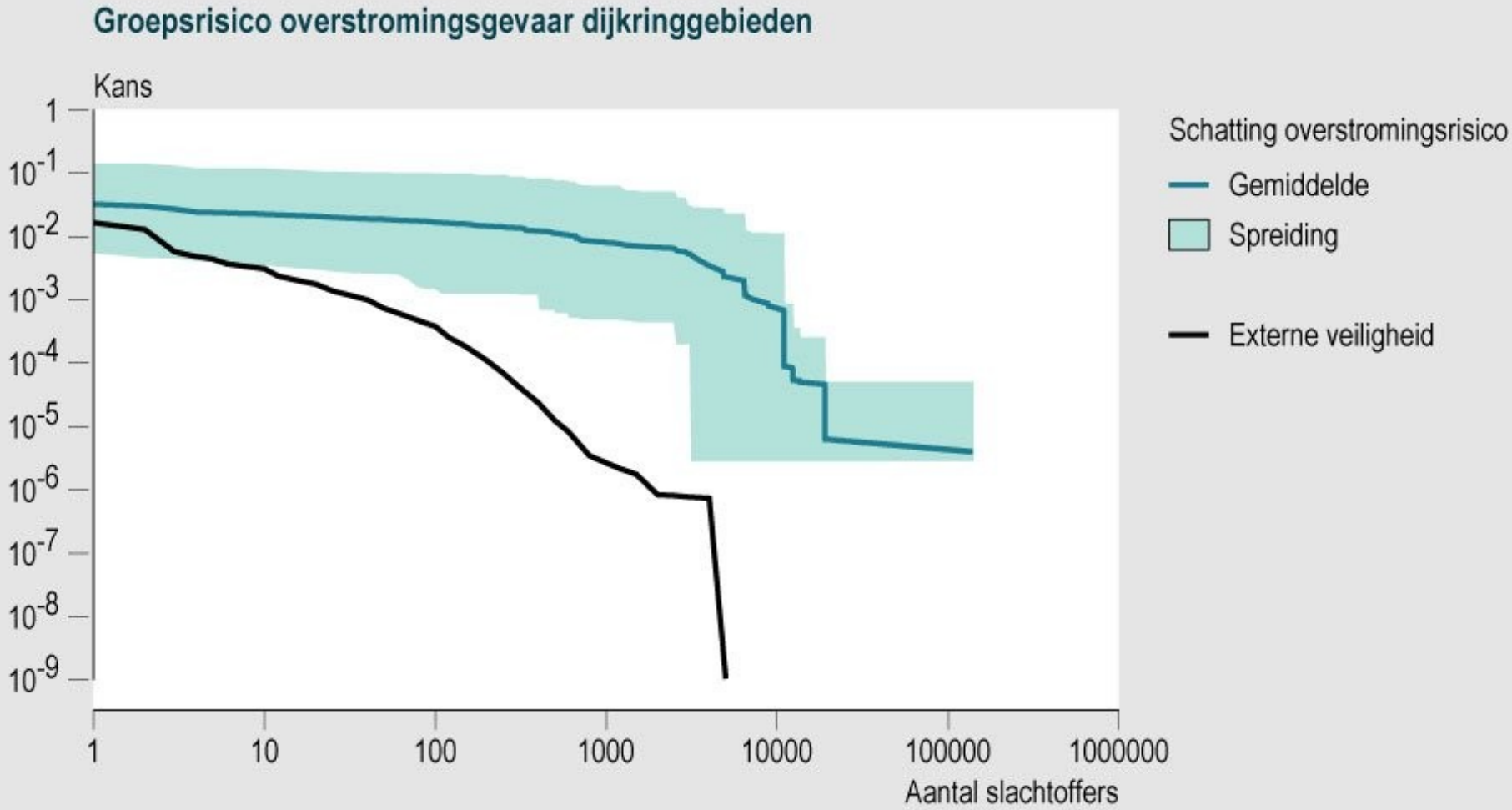
*: Average economic damage for different scenarios

#: bandwidth gives numbers for different scenarios and different situations with respect to evacuation

FN curve
Polder and industrial risk
Case Betuwe, Tieler, Culemborger Waarden



FN Curve


Groepsrisico overstromingsgevaar dijkringgebieden
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10
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1000
10000
100000
1000000
Aantal slachtoffers
Schatting overstromingsrisico
Gemiddelde
Spreiding
Externe veiligheid

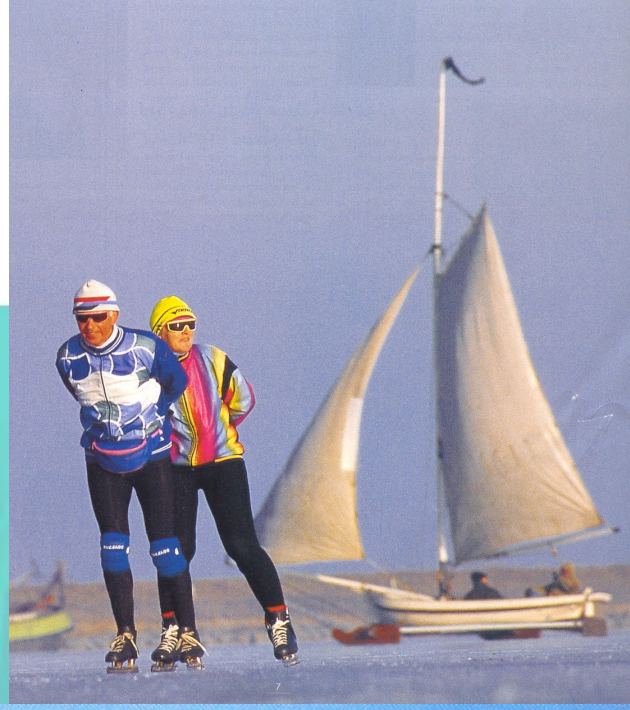
Philosophy of Acceptable Risk

- Two points of view
  - Individual point of view
    - related to equity
    - Minimum safety to everyone
  - Societal point of view
    - related to efficiency
    - Cost benefit analysis
    - FN curves

Risk based approach

Allows us to:

- Identify weak links in the whole system (dike ring, failure mechanisms)
- To balance level of flood protection and societal values that are protected
- Consider a wide range of measures: dike strenghtening, natural protection, spatial planning, evacuation



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